The Recent Erosion in the Vršac Mountain

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Eroziunea recentă a Muntelui Vrsac. Muntele Vrsac reprezintă rămăşitele celor mai vechi munţii din această parte a Europei, ca şi Masivul Rodopi. Este localizat în partea de sud-est a Banatului (sârbesc) una dintre cele trei regiuni ale Voievodinei. În afară de acesta, mai este doar un singur munte în Voievodina, şi anume Fruska Gora, din regiunea Srem. Muntele Vrsac este extins de-a lungul teritoriului Iugoslaviei si României. Are pe axa est-vest o lungime de 15 km . Pe o axă nord-sud lăţimea maximă e de 12 km, iar cea minimă este de 3,5 km. Suprafaţa totală este de 172 km^2, din care partea cea mai mare (122 km^2) se află pe teritoriul Iugoslaviei. Regiunea Banatului (sărbesc) ocupă partea vestică a Voievodinei între Dunăre, Tisa, şi graniţa româno-ungară. În interiorul acestor limite, suprafaţa de 9296 km^2 aparţine Banatului, reprezentând 43% din teritoriul Voievodinei.
S-au investigat factorii antropologici şi cei naturali ce au cauzat eroziunea în Munţii Vrsac. În cei naturali includem factorii geologici, geomorfologici, climatici şi vegetaţia, comparativ cu cei antropologici în care intră influenţa timpurie şi recentă a omului. Îmbinarea factorilor naturali cu cei antropologici a influenţat apariţia unei eroziuni de intensitate medie în partea de nord, şi de intensitate scăzută în partea de sud a Muntelui Vrsac. Totuşi, părţile afectate de eroziune nu au fost reîntărite până în prezent, existând pericolul extinderii acesteia. Pericolul cel mai mare este reprezentat de curenţii torenţiali, ce curg de-a lungul a şapte sate si un oraş. Unele condiţii geologice, geomorfologice şi pedologice reprezintă o predispoziţie pentru apariţia eroziuni liniare şi de suprafaţă. În afară de acest fapt, majoritatea pâraielor au caracter torenţial, cauzând astfel apariţia eroziunii de adâncime. Totuşi, dezvoltarea largă a zonelor împădurite a oprit extinderea eroziunii. Formele erozive care apar cel mai des, sunt ogaşele, alunecările de teren, ravene şi chei. Acumulările de material au format depozite pe marginile versantului nordic şi pe văile din Vrsac-ului. Ca protecţie împotriva eroziunii, noi am sugerat construirea de blocuri susţinătoare şi bazine de retenţie a apelor pe văi, reconstruirea vechilor canale şi trasarea altora noi precum şi împădurirea ariilor aflate în pericol datorită eroziunii apei şi vântului. Construirea caselor pe versanţii cu o anumită înclinare (peste a treia categorie de pante) trebuie să fie interzisă, precum şi desţelenirea şi defrişarea.

Introduction

The Vrsac Mountain represents the remains of the oldest mountains in this part of Europe, i.e. the Rodopi land mass. It is located in the southeast part of Banat, one of the three regions in Vojvodina. Apart from this one, there is only one other mountain in Vojvodina, the Fruska Gora, in the region Srem. The Vrsac Mountain extends across the territory of Yugoslavia and Romania. It stretches along the east-west axis in the length of 15 km. On the north-south axis, the maximum width is 12 km, while the minimum one is 3.5 km. It takes up the total area of 172 km^2, out of which the largest part (122 km^2) lies on the territory of Yugoslavia.

The region Banat occupies the eastern part of Vojvodina within the Danube, the Tisa and the Hungarian and Romanian border. Within these boundaries, the area of 9296 km^2 belongs to Banat, which is 43.2% of the total territory of Vojvodina.
As far as relief is concerned, the following relief elements are present in Banat: the Vrsac Mountain, loess plateaus, the Banat Sand zone, loess terrace, alluvial terrace and inundation areas. The highest peak of the Vrsac Mountain is the "Gudurica" peak whose absolute height is 641m. This peak is not only the highest point of Banat but of the entire Vojvodina as well.

There are two big rivers and a number of smaller ones running through Banat. The two big ones, the Danube and the Tisa, are actually forming the border of Banat. The smaller rivers

are: the Tamis, the Karas, the Nera, the Begej, etc. A considerable number of springs and streams are also found in the Vrsac Mountain.

The climate of Banat is very similar to the climate of Backa. The average air temperature in January is –0,1° C and 21,5° C in June. The southeast wind is the dominant wind in the entire Banat. In addition, the northwest and the north winds often blow here. In Banat, the average amount of annual precipitation is 659 mm.

In the past, Banat was even less inhabited than Backa. The population started to grow after the Turks were driven out and when the Serbian, German, Romanian and Hungarian people settled down. Today, there are 648,611 people living in Banat, i.e. 32.2% of the total population of Vojvodina. The largest ethnic groups are Serbs (455,563 inhabitants), Hungarians (75,865 inhabitants) and Romanians (36,735 inhabitants).

Banat is an agricultural area, yet an area with a well-developed industry. Almost 50% of active population work in agriculture, which provides the 40% of the total national income. The industry branches into 16 sectors. The most important industries are the chemical, the food-processing, the textile and the metal industry. Some of the bigger industrial centers are: Zrenjanin, Kikinda, Pancevo, Vrsac, Kovin, etc.

There are 177 settlements in Banat. As a rule, the rural settlements are large villages with several thousands inhabitants in each.

The Factors That Influence the Appearance of Erosion

Geological Base As a Factor of Erosion

The basic mass of the core of the Vrsac Mountain is composed of shale from the Paleozoic era. Several kinds of gneiss are dominant. The west part of the mountain core is mostly built of biotite gneiss, while in the south part of the mountain the muscovite gneiss is dominant. The east part of the Vrsac Mountain is built of green shale. The main characteristics of gneiss are the following: 1) the gneiss layers are greatly metamorphosed, 2) the tectonic fissures of various dimensions occur very frequently in them, and 3) under the pressure of exogenous forces, the top layer of gneiss disintegrates into finer material which is taken away from the original rock by the torrent and further reduced along the way. The researches have shown that this petrographic structure of the mountain core is suitable for appearance of regressive and deep, ravine-making erosions. It also allows the torrents to carry the loose soil easily and quickly. The lower parts of the Vrsac Mountain are covered by swamp argil sand ground and by sediments from Pliocene (sand, clay). In stream valleys, there are deposits of alluvial sediments (silt clay, sand, gravel). The rocks of gneiss represent the objects for combined influence of surface and deep erosions. These erosions are usually of great proportions and they often threaten the farms in the lower parts of the mountain as well as the very town of Vrsac.

Geomorphological factors of erosion

The Vrsac Mountain consists of four peaks: (from east to west) the "Vrsisor" (463 m), the "Gudurica" peak (641 m) (which is, at the same time, the highest peak of Vojvodina), the "Vrsac" peak (590 m) and the "Vrsacka kula" peak (339 m). These four peaks are separated by three saddles: the saddle "Krokana" (300 m) which lies between the "Vrsisor" and the "Gudurica" peak, the "Kulmea mare" saddle (389 m) which separates the "Gudurica" peak from the "Vrsac" peak and, finally, the saddle "Prevala" (340 m) which separates the "Vrsac" peak from the "Vrsacka kula" peak. On the north and south, the highest parts of the mountain

gradually change into the hilly country, which becomes a plain at approximately 100 m of the absolute height. The asymmetry is expressed on the longer axis. This geomorphological base is a very convenient factor for the occurrence of erosion. The maximum energy of the relief on the north and south slopes is stimulating enough for its appearance. On the north side, it goes from 203% (Donji Vrsisor – foothill) to 315% (the "Vrsacka kula" peak), and on the south, it goes from 58% (Donji Vrsisor – Socica) to 125%, from the "Vrsac" peak to Dumbrava. On very steep slopes, there is no organized linear erosion. Instead, it occurs as denudation, which deposits material, in the form of "avalanche", into the lower riverbeds and on the sides of the Vrsac trench. In the greatest part of the Vrsac Mountain the inclination of the ground does not exceed the 3rd category (over 25%), which means that the cultivation of the land is undesirable. In most cases, this fact is taken into consideration and the largest part of the area consists of woods and grassland. However, in some cases, the disregard of the above regulation can be noticed. In the area between Vrsac and the stream of Malo Srediste, and also in the areas belonging to certain villages (Mesici, Socica, Jablanka) the land is cultivated, which causes the appearance of erosion, especially in the period of torrential rains (Gavrilovic, 1972).

Climate as a factor of erosion

As far as climate is concerned, we have come to the conclusion that precipitation, air temperature and winds have the most important roles in erosion of all other climatic elements. The climate has been described in details in one of our previous works (Bugarski and Tomic, 1987). In the annual distribution of precipitation, there are two wet and two dry periods that stand out. The primary maximum occurs at the end of spring and in early summer. On the average, June is the rainiest month of the year, with the sum of precipitation being 86 mm. The second rainiest month is May (73 mm) and the third one is July (71 mm). The secondary maximum occurs in late autumn and at the beginning of winter (November – December), with the greatest amount of precipitation in December (56 mm). During these months, especially June and July, the rains have the character of strong showers, which can last for several days in some seasons. It is again the summer months that have the highest values of the mean daily maximum: June (29 mm), July (25 mm) and August (27 mm). The absolute daily maximum is highest in August (122 mm) and June (84 mm), while the maximum daily sum of precipitation was 212 mm in July 1975. The frequency of maximum is the result of distribution of showers, which have great kinetic and erosive energy. The bigger mean diameter of the raindrops is also in the favor of this fact. The showers cause heavy periodical washing away. They can also suddenly activate a torrential stream or some other occasional torrents, which have the character of ominous calm most of the time. The primary minimum occurs in early spring, usually in March, and its mean monthly amount of precipitation is 32 mm. The secondary minimum occurs in early autumn (September – October) with the smallest amount of precipitation in October (41 mm). The annual sum of precipitation is 659 mm.

The air temperature changes in accordance with seasons. The highest mean monthly temperatures are noticed in June (21.5° C), and the lowest in January (-0.1° C). The process of rock decay is quickened by the heating of rocks during summer and by their cooling in winter. The characteristics of shale are especially suitable for this process. Shale has heterogeneous mineral structure and texture and it reacts to extreme temperatures by crushing up relatively fast. Thus it makes a base for effective erosive influence of water and wind.

The wind appears as one of the most important climatic elements, if we consider the total share of climatic factors in erosion. From the analyses of the average annual wind frequency (Bugarski and Tomic, 1987), it is clear that a dominant wind in the area of the Vrsac Mountain is the southeast wind – known as "kosava". The frequency of this wind (205‰) is somewhat higher than one fifth of the total occurrence of winds and calms. The southeast winds are most frequent in November (274‰), October (266‰) and March (254‰). In regard to seasons, they are most frequent in autumn (251‰). As far as frequency is concerned,

the southeast wind is followed by the south winds (166‰) and northwest winds (102‰). In the annual distribution of winds and calm, the winds from the north, the northeast, the east, the southwest and the west have the frequency lower than 100‰. The intermediate annual frequency of calm is 160‰. The southeast wind also has the highest mean speed. The mean annual speed is 7.7 m/s, while in January and December the mean speed reaches 9.0 m/s. The researches have shown that it is the southeast wind which strongly influences the appearance of erosion. It carries away the material from the surface of the exposed rocks, as well as from gentle south slopes, which are turned into arable land. In the strong gusts of "kosava", the atmosphere becomes completely turbid with dust.

Hydrography as a factor of erosion

The asymmetry of the transversal profile of the Vrsac Mountain has a considerable influence on hydrographical characteristics. Only the small amount of precipitation that fall on the surface of the steep mountain slopes is absorbed. Most of it flows across the surface of the mountain because of the considerable ground inclination. This is typical for the steep slopes in the "Vrsac – Malo Srediste" zone. There are no permanent currents in this zone. Instead, there are numerous ravines, which become torrents after the strong rains or after the sudden melting of snow. There are only two streams on the north side. The stream of Malo Srediste has its source on the top of a small narrow valley with rather steep sides. Thus, this stream has a relatively small region of convergence. On the other hand, the stream of Markovac has got, in its upper course, a larger region of convergence, thanks to the hilly country across which it flows. Therefore, this stream flows from several sources.

A considerable number of valleys have been carved into the entire south side of the mountain, both in high mountain areas and in low hilly country. These are the valleys of the main streams and their tributaries. Each stream, in its upper course, has a developed head of spring. The carved ground and the thick river network are the result of relatively small incline gradients and specific geological structure. Small incline gradients cause the greater part of the water from the atmosphere to be absorbed by the permeable rocks, while the smaller part of the water flows away on the surface, in the form of torrents. However, this does not mean that there are no torrents on the south side of the mountain. Actually, they commonly occur on denuded and steep slopes after intensive rains. Thus, the south side also has ravines and a considerable amount of suspended deposits. The measurements have shown that the average amount of deposits in one year is 1000 m^3/km^2 on the north slopes. On the south slopes, it accounts to 400-600 m^3/km^2. The former amount relates to the intermediate surface erosion, while the latter one relates to the low surface erosion. However, in the period of torrents, the mass of material exceeds the average values, and than we talk about the high surface erosion.

The ground structure and erosion

In the recent past, some pedogenetic factors have caused the occurrence of a set of different types and varieties of the soil. In the higher parts of the mountain, which are covered by woods, the regosols and the acid brown soil are formed. Due to the presence of woods, the soil has gradually acquired the spongy structure, which enables it to absorb the rain. In this way, the chances for a sudden appearance of torrents and erosions are lowered considerably. In the diluvial zone, where the forest is cleared, the brown forest soil is formed. The foothill areas are full of clay, which is easily saturated with water. These areas are eroded to a great extent, not only because of their structure, but also because of the greater and direct exposure to the precipitation. The degree of the erosion also depends on the incline gradient, which goes from 20-30 %. The abrasive surfaces are mostly covered by brownized smonitza soil on Terciary clays. Considering that these surfaces are located on the south foothill, they are subjects to

erosion and, therefore, numerous ravines are formed on them. The specific structure of the soil provides great possibilities for the development of the erosion. With regard to the fact that these areas are mostly tilled, i.e. they are turned into orchards and vineyards, a big tendency towards further erosion can be noticed.

Vegetation and its influence on erosion

The higher parts of the mountain are almost completely under forests, except for a few small clearings. The forests stretch along the entire longer axis, i.e. from the border with Romania to the "Vrsacka kula" peak. Their lower end is generally around 200 m of absolute height. The forests take up the area of 37 km^2, which is 30.3% of the total mountain area that belongs to Yugoslavia. The forests of the Vrsac Mountain are mostly composed of several different species. The dominant species above 600 m of height are oak and beech. Lower than that, we can find Italian oak, sessile oak, linden tree and hornbeam. The lowest parts are under acacia (locust-tree) and Italian oak. In general, the dominant species are oak (1346 ha), linden tree (668 ha), acacia (513 ha), other deciduous species (330 ha), black pine (44 ha), etc. The forests are thick and the trees have got thick tops. This characteristic provides the gradual rain water absorption of the ground. This is how the erosion can be reduced or even stopped.

The lower parts of the mountain are covered by meadows, pastures and by farmlands. These areas are much more endangered by erosion and by torrents, especially the areas on steep slopes, the ones covered by smonitza soil and the land situated on the exposed parts of the Pliocene sediments.

Anthropogenetic influence on the soil

The human activity in the area of the Vrsac Mountain has taken two directions. Firstly, man has always tried to adapt the mountain, but has often done it inadequately. This is shown through the unplanned clearing of the woods, the ploughing of meadows, the cultivation of plants in the inadequate soil, etc. The ploughing of the terrain above the 3rd category of inclination has been especially stimulating for the erosion. This has been a typical mistake of the owners of the new houses in the area. They have ploughed up the ground, which once represented stable lawns and small groves, and turned it into gardens. The north side of the mountain is particularly at risk. In the area between Vrsac and Malo Srediste, an entire little village has been built. Apart from that, the new roads have been built on the slopes. They are often built inadequately, without strong support and without properly regulated canals. The water runs in torrents across this kind of ground, especially in the period of long and intensive rain showers. Therefore, a complex system of ravines has developed.

Secondly, a lot of effort has been made, especially in the last two decades, to carry out the programs of spatial planning and environmental protection. These programs include planned clearing, planned house building, afforestation of denuded soil, construction of the depots in the courses of torrential streams and regulation of the existing stream valleys.

The forms of erosion in the Vrsac Mountain

In the process of the shale breaking and its washing away, a specific form of rock, called "*ostenjak*", can occur. The loose material, which accumulates in the foot of these rocks, represents the base for the forming of the *alluvial cover*. On the other hand, the loose material on the steep slopes is carried away and, thus, it contributes to the forming of *selective erosive forms*. These forms of erosion can be found on the top of the "Vrsacka kula" peak, on the southwest side of the "Gudurica " peak and south of the "Prevala" saddle.

On the other hand, an entire set of *denudation forms* has been made by the erosive activity of the running water. The *furrows* represent the smallest linear erosive forms and they are formed on the sides of the ravines. They can be 2.5 m long, while their depth depends on the inclination of the side in which they are cut. On small inclines, the depth of a furrow can account to 20 cm. In cases when the ravine sides stand vertically, the furrows are replaced with the forms that are the result of earth cracking. Likewise, when the shale is present in the ground, the appearance of the furrows depends on the direction in which the layers of shale are stretching. Thus, they are rather shallow (around 5 cm) if located in the highly inclined layers, while they do not appear at all in the horizontal layers. The most frequent form of disintegration is the mechanical one and its process is quickened by torrents and by strong showers. Another kind of erosive form is a *landslide*. Landslides are usually caused by the movements of the loose material, or more exactly, by the movements of vertical sides of ravines and gorges. The supportive ground gets disturbed by the activity of torrential waters, and causes the loose soil to move, under the influence of gravity, and to form deposits on the bottom of the riverbed. This kind of movement often denudes the roots of saplings and, thus, it makes them unstable. It can also move the big trunks or even knock them down. The appearance of landslides is partly caused by people who cut trees and shrubs around the edges of riverbeds. The research has shown that the appearance of landslides is most prominent in the places where the shale foot is covered by a thin layer of clay with the loose soil on top of it.

The most frequent erosive forms are *ravines* and *gorges*. A large number of ravines occurs on the north side of the mountain, especially between Vrsac and Malo Srediste. A ravine is formed from several small canals converging into the main one. Several completely formed ravines can be seen in the stream basins of Malo Srediste, Mesici and Guzajna. The length of these ravines goes from 1 km to 4 km and they are from 1 to 5 m deep. They usually occur in the alluvial cover, while their bottom is cut into the shale, clay or argile sand ground. Their inclination varies, especially when the base ground is of unequal strength. The appearance of gorges is preceded by the forming of long shallow *grooves* made by linear merging of the rain and snow water. The grooves lengthen and deepen regressively and, thus, they turn into ravines and gorges branching in the upper part of the basin. In the basin of the "Mesici" stream, in the process of horizontal erosion and intensive washing away, the bottom is broadened into the miniature alluvial plateaus. In the cases of gorges which border directly on stream valleys, the erosive base is stabilized, so that their forming has reached the balance (Romelic, 1991).

The accumulative forms are less frequent on the bottom of ravines and gorges. However, the most distinctive forms (in the morphological sense) are *deposits* on the border of north slopes and the trench of Vrsac. Deposits are formed in the process of accumulation of the material carried by the torrents. The torrential waters carry away not only broken shale, surface sediments and top soil, but the material from the old dead deposits, as well. In that way, the new deposits are added to the old ones. The most distinctive and, at the same time, the most endangered deposits are the ones covered by woods. Yet, in the period of showers, when the ravines are activated to the maximum, the water gets through the loose soil of the mountain. Thus, the water penetrates the soil of the "Vrsac" trench and, because of the difference in altitude, it breaks out from the trench as a jet of water. This is characteristic of the occasion when the period of showers follows the long dry period, which has previously caused the earth to crack in long, wide lines (Zeremski, 1985).

Conclusion

The combination of natural and anthropologic factors has influenced the appearance of erosion of medium intensity in the north part, and of low intensity in the south part of the Vrsac Mountain. However, the damaged areas have not been reinforced so far, and there is still a danger of the spreading of erosion. The greatest damage is caused by torrential streams, which

flow through seven villages and one town. To reduce the damage caused by erosion, a series of protective measures have to be taken.

Supportive blocks and depots for water should be built in the ravines and torrential streams. The depots should be built on the narrow sections of the riverbed. Their role would be to accumulate the undue water and torrential deposits. The blocks should consolidate the banks and keep them from collapsing.

In order to consolidate the ground and prevent the surface water from flowing down the slopes, a network of canals should be built, which would direct the water towards the trench of Vrsac. Apart from this, it is necessary to renovate the old canals, since they often become overgrown with thick bushy vegetation and sometimes, they even get piled with litter.

It is necessary to stop the building of houses on the north side of the mountain. Likewise, one should prevent the turning of pastures and woods into the arable land and gardens, in the areas where the incline gradient is above the 3rd category.

It is also necessary to carry out the planned clearings and the afforestation of the cleared areas and bare terrain. A certain number of wind-breaks should be made in order to reduce the wind erosion.

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